Major-element chemical variations clearly play an important role in Earth's mantle, influencing the thermal evolution of both mantle and core, as well as (trace-element) geochemical signatures of erupted basalts and seismically-observed structure. In a series of papers we have studied the thermo-chemical evolution of the Earth using numerical models that include self-consistently generated plate tectonics, melting-induced crust formation, decaying heat-producing elements, a cooling core, and (recently) a self-consistent mineralogical treatment, in both 2- and 3-dimensions. These models indicate the importance of dynamically-induced chemical layering by the settling of subducted MORB above the CMB, dynamically-induced chemical and flow layering by the action of multi-component phase transitions near 660 km depth, the influence of MORB composition on chemical layering, and the strong influence that compositional variations have on core dynamics and evolution. In recent models we study the long-term dynamics of a primordial dense layer, identifying the parameter range under which thermo-chemical structures match those from probabilistic seismic tomography, and finding that such a layer may be consistent with geochemical constraints on Helium ratios of ocean island basalts. The post-perovskite phase in the deepest mantle may also play a significant role, particularly if it has a lower viscosity than perovskite as recent ab initio results suggest. This presentation will give a synthesis of these results and also discuss how our knowledge of such things has greatly benefited from the seminal work of Geoff Davies.